

## **METHOD AND APPARATUS FOR KILLING INSECTS BY TRAPPING LARVAE**

### **RELATED APPLICATIONS**

5           This application claims priority to U.S. Provisional Application No. 60/413,963 filed on September 26, 2002 and entitled MOSQUITO LARVA TRAP, which is incorporated herein in its entirety.

### **TECHNICAL FIELD**

10           This invention relates in general to insect control, and in particular to the capture and killing of insects such as mosquito larvae before they become adult biting mosquitoes.

### **BACKGROUND**

15           Mosquitoes are more than just an annoying problem. From the 1800s when British Army Doctor Donald Ross proved malaria was transmitted by mosquitoes, to the present United States outbreak of the mosquito borne West Nile virus, mosquitoes have proven to be a serious problem for both man and animals. Some other diseases transmitted by mosquitoes are dengue, yellow fever, and encephalitis varieties such as  
20   Eastern Equine encephalitis, Western Equine encephalitis, La Crosse encephalitis, St. Louis encephalitis, and Japanese encephalitis.

          The quest to prevent mosquito transmitted diseases and the general annoyance of being bitten while engaged in outdoor activities has been long and generally unsuccessful. Primary methods of control have been directed at large scale sprayings of  
25   indiscriminate poisonous chemicals, attractant traps directed at killing adult mosquitoes, draining of breeding areas such as wetlands, or the application of larvicide chemicals in bodies of water.

          Many poisonous chemicals not only kill mosquitoes, but also destroy beneficial insects as well as having detrimental effects on other wildlife such as birds. DDT is still  
30   a cause of ecological damage after over thirty years of non-use in the United States. Draining of wetlands has been recognized as destructive to the overall health of our

environment and the use of larvicide chemicals in these areas is expensive, requires repeated applications during the breeding season, and could have long term side effects as yet undetermined. Various types of traps have been introduced that attract adult mosquitoes by the use of light, emissions of chemical attractants, carbon dioxide releases, and even vibrating membranes that mimic animal skin. The killing mechanisms used by these traps tend to be electrocuting devices, vacuuming insects into holding bags, introducing the insects to poisonous chemicals, or providing a sticky surface on which the insects become trapped. Many of these traps are expensive to produce and require extensive maintenance for their operation.

All of the above trapping methods result in the unintended destruction of beneficial insects. Current studies indicate existing commercially available traps such as the light attractant and carbon dioxide emitting varieties tend to attract disproportionately greater numbers of mosquitoes to an area than they actually kill. This action creates a negative impact on the intended result of mosquito elimination from a particular location.

It has also been shown that the ratio of beneficial insects killed versus mosquitoes by many of these devices is sufficiently high that quite a few of these traps are actually regressive to the environment.

Mosquito populations grow exponentially with one adult female laying from a few to over one hundred eggs every third day of her breeding life. Obviously, the attracting and killing of individual mosquitoes using existing art is, at best, a check-stop measure as the existing art fails to kill mosquitoes in large numbers and break the cycle that allows the exponential growth of the population.

## SUMMARY

Embodiments of the present invention address these issues and others by providing a method and apparatus that captures mosquito larvae to prevent them from developing into adult mosquitoes that are otherwise free to continue to reproduce and cause harm. Embodiments provide an attractive location for mosquitoes and other harmful insects to lay eggs while trapping and killing the larvae developing from these eggs and/or trapping and killing adult mosquitoes that have developed from the trapped larvae.

One embodiment is an apparatus for killing insects. One preferred design of the apparatus includes a container and a protrusion within the container, in which at least a portion of the protrusion is preferably sloped relative to horizontal. The apparatus also includes a directing member within the container that is positioned above the protrusion and having at least a portion that is non-horizontal. The directing member defines an opening that is located above the protrusion. The protrusion, directing member, and container define a chamber that for containing insect larvae and prevent those larvae from maturing into insects or, if they mature, from exiting the container.

Another embodiment is a method of killing insects with a container, such as the one described above. The method involves placing liquid in the container so that the liquid level is above the opening of the directing member and partially fills the chamber. The container is positioned such that insect eggs are laid on the liquid surface and the insect eggs hatch into larvae. The method further involves directing or guiding the larvae to drop from the liquid surface along the directing member and out of its opening. After the larvae pass through the opening, the method preferably further involves directing the larvae to further drop or otherwise move into the chamber. When the larvae reach this location, they have little chance of surviving and exiting the chamber alive.

Another preferred embodiment of the present invention includes a container and an inverted cone member within the container. A funnel-shaped member is located within the container above the inverted cone and defines an opening above the inverted cone. The embodiment further includes a barrier that has a first edge that abuts the underside of the funnel-shaped member and has a second edge that abuts the container. At least the barrier, the funnel-shaped member, and the container define a chamber.

Additional embodiments of the present invention include a container and a floor within the container, and the floor may include at least a portion that is sloped relative to the horizontal. A directing member is positioned above the floor and has at least a portion that is non-horizontal. The directing member defines an opening above the floor. The floor, directing member, and container define a chamber that traps the insect larvae. The container may be translucent while the directing member may be opaque such that the larvae are drawn away from the opening and further into the chamber toward the sidewall regardless of whether the bottom is sloped or flat.

## DESCRIPTION OF THE DRAWINGS

5           FIG. 1 is a front view of an illustrative container of one embodiment showing a concave bottom and a protrusion centered on the container bottom.

          FIG. 1.1 is a top plan or birds-eye view of the container of FIG. 1 showing center alignment of the protrusion.

          FIG. 2 is a front view of an illustrative funneling device of one embodiment that  
10 fits into the container of FIG. 1.

          FIG. 2.1 is a top plan view of the funneling device of FIG. 2 showing center alignment of its lower opening.

          FIG. 3 is a top plan view of an illustrative ascension barrier of one embodiment.

          FIG. 3.1 is a front view of the ascension barrier of FIG. 3.

15           FIG. 4 is an exploded front view of one embodiment of the present invention showing the assembly process.

          FIG. 5 is a front cross-sectional view of the assembled embodiment shown in FIG. 4.

          FIG. 5.1 is a cut away cross-sectional view of an illustrative snap-on lid portion of  
20 the funnel of FIG. 2 connected to the container of FIG. 1.

          FIG. 6 is an isometric cross-sectional view of FIG. 5.

          FIG. 7 is an alternative cross-sectional view of FIG. 5 after water has been placed into the container to a level adequate to drown the larvae.

          FIG. 8 is an alternative cross-sectional view of FIG. 7 after water has been placed  
25 into the container to a level adequate to trap adult mosquitoes that have developed from the trapped larvae.

          FIG. 9 is a front cross-sectional view of one assembled alternative embodiment that has a sloped bottom within the container.

          FIG. 10 is a front cross-sectional view of one assembled alternative embodiment  
30 that has a flat bottom within the container.

## DETAILED DESCRIPTION

The present invention is more particularly described in the following examples that are intended as illustrative only since numerous modifications and variations therein will be apparent to those skilled in the art. As used in the specification and in the claims, “a,” “an,” or “the” can mean one or more, depending upon the context in which it is used. The preferred embodiment is now described with reference to the figures, in which like numbers indicate like parts throughout the figures.

The present invention provides a trap for insect larvae, in particular mosquito larvae, and a method of using such a trap. The larvae are contained so that they either drown or develop into adult mosquitoes that are unable to exit and eventually starve, depending upon the particular embodiment of the present invention and the corresponding level of liquid being used. The present invention, accordingly, assists in breaking the cycle of the exponential increase in mosquito populations.

One preferred embodiment of the present invention comprises a container, a protrusion or inverted cone member, a directing member or funnel, and, optionally, a barrier. FIG. 1 is a front view of an exemplary container 50 according to one embodiment, in which a vertical axis V bisects the center of the container 50 and is used for reference throughout the drawings. In this embodiment, the container 50 is shown as being round in shape, but other shapes including polygons of various numbers of sides are also applicable. The container 50 may be made from various materials such as plastic or metal. However, translucent plastic allows the inside of the container 50 to be viewed by an observer to verify the functioning of the apparatus and also allows light to enter the container to further draw the larvae toward the light, as discussed below.

The container 50 includes various attributes. A sidewall 62 of the container 50 may optionally include a ledge 18 for an optional ascension barrier, discussed below, to rest on with the ledge 18 so as to separate an upper sidewall region 16 from the remainder of the sidewall 62. In this embodiment, a bottom surface 20 of the container 50 is concave to have a slight inward taper or slope forming a raised base.

Still referring to FIG. 1, a modified conical structure 22, which is an inverted cone, is positioned on the apex of the bottom 20. The conical structure 22 of this embodiment has a first sloped region 52 and second sloped region 54, with the top sloped

region 52 having less slope. The taper of the bottom surface 20 of the container 50 has an even lesser slope extending between the conical structure 22 and the sidewall 62. As one skilled in the art will appreciate, if an object falls or drifts into the center of the container bottom 20, the conical structure 22 and concave design of the bottom direct that  
5 object toward the sidewall 62 of the container 20. Other manners of obtaining this same effect with the bottom 20 is to have a parabolic cross-section between the sidewall 62 and center or to have a consistent slope extending from the apex to the sidewall 62. As discussed below in relation to FIG. 9, other formations for the bottom of the container are applicable as well, such as having a substantially planar bottom of the container that is  
10 either flat or sloped relative to the horizontal and spans the diameter of the round bottom of the container 50.

FIG. 1.1 is a top plan view of the container 50 depicting a 'y' axis Y and the perpendicular 'x' axis X in center alignment along with the top rim 14, which is also shown in FIG. 1. The optional ledge 18 is also shown, on which the optional ascension  
15 barrier may rest. The modified conical structure 22 of this particular embodiment is also shown. Optional holes 42 allow a simple bent wire handle (not shown) to be connected to the container 50 to facilitate carrying it.

The present invention also preferably comprises a non-horizontal top surface to assist in directing or guiding larvae downwardly, and FIG. 2 shows a funnel 60 that is one  
20 exemplary embodiment. The funnel mounts within the container 50 and has a funnel sidewall 26, funnel top opening rim 24, funnel bottom opening rim 30, and optional funnel vent holes 28, which allow air trapped during the filling process to escape when the apparatus is filled with liquid after being assembled. Such vent holes 28 are not  
25 necessary when ventilation is not required, such as when the container 50 is filled with liquid prior to the additional components such as funnel 60 being inserted into the interior of the container 50. The top opening rim 24 preferably attaches onto the top rim 14 of the container 50 by interlocking together, which is shown in FIG. 5.1.

As discussed in more detail below, the sloped sidewall 26 of the funnel 60 directs larvae to the bottom rim, which defines an opening 30 therethrough. In use, the sinking  
30 or downwardly moving larvae pass through the opening to the bottom surface 20, where they are directed toward the sidewall 62 of the container 50 and away from the opening

30. Thus, the slope of the sidewall 26 of the funnel 60 directs the larvae to its opening, and then once through, the slope of the bottom surface directs the larvae away from the opening to decrease the likelihood of reentry into the interior of the funnel 60. As discussed above, the conical structure 22 further assists in directing the larvae to the  
5 sidewall of the container and impedes the larvae from reentering into the interior of the funnel 60.

The sidewall 26 of the funnel 60 may be constructed of various materials such as plastic or metal. However, a dark, visible light-absorbing coloring provides the most attractive location for eggs to be laid by the harmful insects, such as biting mosquitoes.

10 A black non-horizontal top surface is especially attractive to mosquitoes. Having an opaque funnel also prevents light from entering the container near the opening 30 such that larvae are not attracted back toward the opening after the larvae have already passed through it.

One skilled in the art will appreciate that the slope of the sidewall 26 of the funnel  
15 60 can vary. One consideration is that the opening 30 is sufficiently small so that the larvae cannot easily reenter the interior of the funnel after exiting it. The slope is also a function of the dimensions of the container, *i.e.*, a shorter container with a wide top opening will use a different slope than a taller container with a narrow top opening. One contemplated embodiment of the funnel 60 has a top opening rim 24 having a diameter of  
20 7.25 inches inside the rim and 8 inches outside of the rim; a bottom opening 30 with a diameter of one inch, a vertical height between the top and bottom openings of 4 inches, and an included angle of 77 degrees relative to horizontal to define the slope. It should be noted that these dimensions are provided only for purposes of illustration of one embodiment and that various other dimensions are also applicable. Accordingly, these  
25 dimensions are not intended to limit the scope or meaning of the claims.

While the funnel 60 provides a suitable non-horizontal top surface for the illustrated embodiment, various other non-horizontal top surfaces may also be used. For example, an inverted cone could be utilized in which the inverted cone provides a slope leading to one or more openings along the outer rim rather than providing an opening in  
30 the center, such that the larvae are directed downward and toward the outer portion of the cone and through openings at the outer portion. However, where such an inverted cone is

utilized to provide a top slope, the bottom surface of the container is provided a reversed slope, which leads from the sidewall 62 downward to a center location to direct the larvae to the center of the bottom surface, which is away from the openings of the top surface. Other examples of a non-horizontal top surface include having a consistent slope leading across the diameter of the container 50 with an opening defined by the surface in proximity to the sidewall 62 or having a vertical surface extending downward but terminating above the sloped bottom surface to define an opening.

FIG. 2.1 shows the funnel bottom opening rim 30, optional funnel vent holes 28, and the optional alignment holes 42 for handle insertion.

Referring now to FIG. 3, the optional ascension barrier 80 is shown having optional vent holes 32, an outer rim 34, and an ascension barrier-locking ring 36. The barrier 80 rests on the ledge 18 of the container 50 and the barrier-locking ring 36 defines a hole in the center into which the funnel 60 is received such that the opening 30 of the funnel 60 is located below the ledge 18 and ascension barrier 80. The barrier-locking ring 36 complementarily receives and contacts the underside of the funnel 60 to create a barrier between the funnel 60 and sidewall 62 of the container 50. The ascension barrier 80 may be constructed of various materials such as plastic or metal. As noted above for the funnel 60, the vent holes 32 of the ascension barrier are optional and are not necessary when the apparatus is assembled after the liquid has already been poured into the container 50. The vent holes 32 are preferably of a dimension such that the larvae cannot easily pass through them, if at all.

FIG. 3.1 is a front view of the ascension barrier 80 showing the outer rim of ascension barrier 34 and funnel-locking ring 36. From this view, it can be appreciated that once installed, the outer rim 34 contacts the ledge 18 of the container while the funnel-locking ring 36 contacts the funnel 60 such that a barrier is created. This barrier 80 may be included in the apparatus where the liquid is filled above the barrier 80 so that larvae cannot reach the surface of the water due to the barrier and drown. Including the barrier 80 allows this mode of operation to occur without requiring that the liquid be filled all of the way to the top rim 14 of the container. However, other modes of operation will also serve to kill the harmful insects, as discussed below.



FIG. 4 provides an exploded view of one illustrative embodiment of the apparatus 10 of the present invention, in which the funnel 60, the optional ascension barrier 80, and the container 50 are correctly aligned for assembly. Thus, for this embodiment, the optional barrier 80 is first placed into the container 50 and is seated on the ledge 18.

5 Then the funnel 60 is placed into the container 50 where it is seated within the locking ring 36 of the barrier 80 and fits onto the top rim 14 of the container 50.

FIG. 5 shows the assembled apparatus 10. A detailed view of a funnel-locking ring 40, which is snapped into place over the top rim 14 of the container 50, is shown in FIG. 5.1. As noted above, the funnel sidewall 26, directs the larvae in a downward  
10 direction toward and out of its opening 30, where they are further directed away from this opening by the conical structure 22 and further encouraged to move away from this area by the concave bottom 20 of the container 50. At this point, the larvae are in an entrapment chamber 38, which is defined by the bottom 20 of the container 50, sidewall 62 of the container 50, sidewall 26 of the funnel 60, the conical structure 22, and the  
15 barrier 80 if present.

Referring now to FIG. 6, the apparatus 10 is shown in cross-section, in which the funnel 60 is connected to the container 50 by the funnel-locking ring 36 at the ledge 18 of the container 50. The sidewall 26 of the funnel 60, with optional vent holes 28, slopes to the bottom rim 30 of the funnel 60 which opens into the entrapment chamber 38 by  
20 passing around the conical structure 22, which is a molded part of the concave bottom 20 of this embodiment but could be a separate component installed within the container 50. Larvae attempting to get to the surface of the liquid to breathe while in the entrapment chamber 38, are blocked by the barrier 80, which is held in place below the surface of the liquid by both the ascension barrier collar 36 and ledge 18, and the larvae drown.

25 In operation the assembled structure 10 is filled to a particular level with liquid. Such liquid may be water from any source, utilizing anything from a stagnant pool to fresh tap water. The water is filled to at least a level above the bottom opening 30 of the funnel 60. As discussed above, the apparatus 10 may be assembled prior to filling with water. In that case, ventilation holes in the ascension barrier 80, if the barrier 80 is  
30 present, and in the funnel 60, allow air to escape as the water displaces it. In addition to water, oviposition material 120 as shown in FIGS. 7 and 8 may be placed in the apparatus

10 to advance the stagnation of the water so as to draw mosquitoes more quickly. That is, the oviposition material depletes oxygen from the water, which also accelerates the drowning of the trapped larvae. Examples of such oviposition material include non-animal fat materials such as pot-bellied pig chow, oatmeal, alfalfa, rice hulls, and  
 5 brewer's yeast. While oviposition material containing animal fat such as rabbit pellets may be used to further stagnate the water, a layer of grease may form on the water surface thereby lessening the attraction of mosquitoes to use the apparatus 10.

The apparatus 10 is placed in a location where it is likely that mosquitoes will be present to lay eggs. For example, the apparatus may be placed in a shaded area  
 10 preferably in grassy locations or near bushes. As shown in FIGS. 7 and 8, mosquitoes are attracted to the still water 100 (FIG. 7), 100' (FIG. 8) present atop the funnel 60 and lay their eggs 102 within it.

The eggs 102 float on top of the water 100, 100' until they hatch into larvae 104 approximately twenty-four to forty-eight hours later. The larvae 104 breathe at the  
 15 surface of the water 100, 100' instead of ingesting oxygen from the water itself, and drift or swim to the bottom to hide. The funnel sidewall 26 directs the larvae 104 down and toward the center where they emerge from the bottom opening 30 of the funnel 60, and are directed into the entrapment chamber 38, and away from the bottom rim 30 of the funnel 60 by the conical structure 22, and also by the light entering through the container  
 20 50, if translucent. Once within the entrapment chamber 38, the concave bottom 20 of the container 50 encourages further movement away from the bottom opening 30 of the funnel 60 toward an outer region 106.

As shown in FIG. 7, when the need for oxygen causes the larvae 104 to swim toward the surface of the water 100, they are blocked by the ascension barrier 80, and  
 25 drown at a region 108 since the water 100 has been filled to a level above the barrier 80. In trials, an occasional larva 104 found its way out of the entrapment chamber 38 and back through the bottom rim 30 of the funnel 60. However, if that occurs, the process starts again by that larva 104 again swimming downwardly back in the entrapment chamber 38, where it will drown.

30 The method of killing the insects as shown in FIG. 7 may also work without the ascension barrier 80 present if the water 100 is filled all the way to the rim 24 of the

funnel 60. Thus, once the larvae 104 enter the entrapment chamber 38 and begin to swim upward toward the surface, the larvae encounter the underside of the funnel 60 and drown.

FIG. 8 shows the water level in the apparatus 10 below the ascension barrier 80 but above the bottom rim 30 of the funnel 60. The apparatus 10 continues to work but uses a different method. In this situation, larva confined to the entrapment chamber 38 can reach the surface of the water 100' to breathe and eventually mature into adult mosquitoes 112. However, because adult mosquitoes 112 cannot swim underwater, they remain trapped in the entrapment chamber 38 and quickly die of starvation. In this scenario, the ascension barrier 80 continues to be optional because once the adult mosquito 112 develops, the underside of the funnel 60 traps the mosquito 60 if the barrier 80 is not present.

The converse of this scenario of a low water level is too much rain, which overflows the apparatus 10. Since the apparatus is designed to work at full water depths as noted above, either with or without the ascension barrier, heavy rains do no harm with the excess simply spilling over the side. Any eggs 102 or larvae 104 that spill over onto the ground with the excess water quickly die of dehydration since they must be in water to survive.

FIG. 9 shows one of the various alternatives to the embodiment shown in FIGS. 1-8. The apparatus 90 of FIG. 9 includes a container 50' having a bottom 92 that forms a sloped surface relative to horizontal, as opposed to including a protrusion such as the conical structure 22 of FIGS. 1-8. The sloped surface of the bottom 92 directs the larvae toward the sidewall 62 upon the larvae passing through the opening 30 of the funnel 60. The larvae are then trapped within the entrapment chamber 38' defined by the bottom 92, sidewall 62 and funnel 60 where they drown or starve once an adult mosquito. As with the previous embodiment, the ascension barrier 80 may be included to further define the entrapment chamber 38'.

It will be appreciated that the bottom 92 of this embodiment may be substantially planar, parabolic, concave, or of other curvature that slopes away from the opening 30 and into the entrapment chamber 38'. Furthermore, it will be appreciated that the bottom 92 may also be augmented at the area below the opening 30 with a protrusion such as a

conical structure as described above. Additionally, it will be appreciated that the funnel 60 may be opaque while the container 50 is translucent to further discourage the larvae from swimming toward the opening 30 while encouraging the larvae to swim toward the sidewall 62 and further into the entrapment chamber 38'.

5           FIG. 10 shows another of the various alternatives to the embodiments shown in FIGS. 1-9. The apparatus 150 of FIG. 10 includes a container 50" having a bottom 92' that is flat relative to the horizontal, as opposed to forming a sloped surface relative to horizontal and as opposed to including a protrusion such as the conical structure 22 of FIGS. 1-8. The flat surface of the bottom 92' may not direct the larvae toward the  
10           sidewall 62 upon the larvae passing through the opening 30 of the funnel 60, but some larvae will swim toward the sidewall 62 without the direction from the bottom 92'. The larvae are then trapped within the entrapment chamber 38" defined by the bottom 92', sidewall 62 and funnel 60 where they drown or starve once an adult mosquito. As with the previous embodiments, the ascension barrier 80 may be included to further define the  
15           entrapment chamber 38". The level of the liquid that is used to fill the container is at least above the opening 30 but may either be above or below the ascension barrier 80.

          It will be appreciated that the that the funnel 60 may be opaque while the container 50 is translucent to further discourage the larvae from swimming toward the opening 30 while encouraging the larvae to swim toward the sidewall 62 and further into  
20           the entrapment chamber 38". Thus, while the bottom 92' may not provide direction to the larvae, the light entering through the translucent container 50" will provide the effect of drawing the larvae toward the sidewall 62 and further into the entrapment chamber 38".

          The exemplary apparatus and designs illustrated and discussed above in relation to FIGS. 1-10 may include several individual components. These components may be  
25           individually formed and assembled to complete the apparatus or one or more of these components may be integral with another. It will be appreciated that whether to have the components separately formed and assembled or as integral components formed together at the time of manufacture is a matter of design choice. Additionally, it should be noted that the non-horizontal directing member above the bottom 92 may be shaped in other  
30           ways. For example, the opening 30 may be defined at various locations other than in the

center, such as in proximity to the sidewall 62 at a location that is near the upper intersection of the bottom 92 and the sidewall 62.

5 The various embodiments described above are provided by way of illustration only and should not be construed to limit the invention. Those skilled in the art will readily recognize various modifications and changes that may be made to the present invention without following the example embodiments and applications illustrated and described herein, and without departing from the true spirit and scope of the present invention, which is set forth in the following claims.